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AB The title **steel** contains **C** 0.20-0.70, Si .ltoreq.1.50, **Mn** 0.30-2.00, P .ltoreq.0.15, S .ltoreq.0.10, Cu .ltoreq.0.20, Ni .ltoreq.0.50, Cr 0.02-2.00, Mo .ltoreq.0.50, V .ltoreq.0.50, Nb .ltoreq.0.17, Ti .ltoreq.0.20, B .ltoreq.0.0100, Al .ltoreq.0.100, N .ltoreq.0.030, and Pb .ltoreq.0.30 wt.% satisfying fn6 .gtoreq.0 and fn1 .gtoreq.0, fn2 .gtoreq.0, fn3 .gtoreq.0, fn4 .ltoreq.0, and/or fn5 .gtoreq.0 [fn1 = Si + 2V - 0.5, fn2 = Si + 2V + 5P - 0.8, fn3 = N - 0.1Al - 0.002, fn4 = N - 0.3Ti, fn5 = N - 0.5Al - 0.3Ti - 0.15Nb - 0.3V - 1.3B - 0.002, fn6 = **C** + Si/10 + **Mn**/5 + 5Cr/22 + 1.65V - 5S/7 - 0.8 (the element symbols represent wt.%)]. Automobile engine connecting rod and cap can be prepd. from the **steel** by integral forging and sepg. at room temp.

0.2-0.7 C
≤1.5 Si
0.3-2 Mn
≤0.15 P
≤0.1 S
≤0.2 Cu
≤0.5 Ni
0.02-2 Cr
Fe

PATENT ABSTRACTS OF JAPAN

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(54) NON-HEAT TREATED STEEL WITH HIGH STRENGTH AND LOW DUCTILITY

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a steel having high strength and low ductility, capable of division working at ordinary temp., having a resultant division fracture surface showing flat brittle fracture surface, and suitably used as a steel for connecting rod.

SOLUTION: This steel has a composition consisting of, by weight, 0.20-0.70% C, ≤1.50% Si, 0.30-2.00% Mn, ≤0.15% P, ≤0.10% S, ≤0.20% Cu, ≤0.50% Nu, 0.02-2.00% Cr, ≤0.50% Mo, ≤0.50% V, ≤0.17% Nb, ≤0.20% Ti, ≤0.0100% B, ≤0.100% Al, ≤0.030% N, ≤0.30% Pb, and the balance Fe with inevitable impurities, satisfying at least one kind among Si+2V-0.5≥0, Si+2V+5P-0.8≥0, N-0.1Al-0.002≥0, N-0.3Ti≤0, and N-0.5Al-0.3Ti-0.15Nb-0.3V-1.3B-0.002≥0, and also satisfying C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8≥0, where the symbol of element in the relationships represents its content by weight per cent.

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CLAIMS

[Claim(s)]
[Claim 1] High intensity and low ductility non-heat-treated steel characterized by the following. By weight %, C:0.20 - 0.70%, less than [Si:1.50%], Mn:0.30-2.00%, P:0.15% or less, S:0.10% or less, less than [Cu:0.20%], nickel: Less than [0.50%], Cr:0.02-2.00%, less than [Mo:0.50%], V:0.50% or less, less than [Nb:0.17%], less than [Ti:0.20%], B:0.0100% or less, less than [aluminum:0.100%], N:0.030% or less, less than [Pb:0.30%]. The remainder consists of Fe and an unescapable impurity, and fills at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0, and is fn 6>=0. However, fn1=Si+2V-0.5, fn2=Si+2V+5P-0.8, fn3=N-0.1aluminum-0.002, fn4=N-0.3Ti, The symbol of element in fn5=N-0.5aluminum-0.3Ti-0.15Nb-0.3V-1.3B-0.002, fn6=C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8, in addition a formula expresses the content in weight % of the element.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Although, as for this invention, high intensity is required in more detail about high intensity and low ductility non-heat-treated steel, rather, it is not needed, but cold division processing in ordinary temperature is possible for ductility, the fracture surface presents a flat brittle fracture appearance, and it is related with high intensity and low ductility non-heat-treated steel suitable as a material connecting rods, such as an automobile engine, and for connecting-rod caps.
[0002]
[Description of the Prior Art] joint - After hot forging of the main part 1 and connecting-rod KYAPU (common-name connecting rod cap) 2 of a connecting rod (common-name connecting rod) which are shown in drawing 1 which is parts, such as an automobile engine, was conventionally carried out at another process, temper processing of hardening annealing was performed to them, and subsequently, they finished with processing of the bolthole by machining, received plastic surgery processing, and were assembled with the bolt 3 after that by the crankshaft with a complicated configuration.
[0003] However, the movement of manufacturing-cost reduction of various autoparts is activating recently reflecting the severe economic situation, and this movement is no longer an exception also in engine parts.
[0004] For this reason, about the aforementioned connecting-rod main part 1 and aforementioned connecting-rod KYAPU 2, both are really fabricated with hot forging, and hardening annealing is heat-treated to this as a cure against manufacturing-cost reduction, or it cools radiationally after hot forging, and divides into the connecting-rod main part 1 and connecting-rod KYAPU 2 after that, and the method of combining with a crankshaft and assembling machining for the finishing plastic surgery to a joint (planes of composition) with a bolt 3, without giving, is examined. By this method, before processing of a bolthole divides the aforementioned one fabrication material, it is performed behind.
[0005] How to give and divide the force committed in the direction shown by the arrow in drawing 1 by inserting a fixture, for example as a method of dividing the really [above-mentioned] fabricated connecting-rod main part 1 and connecting-rod KYAPU 2 can be considered. By this method, it becomes very important to make into a flat the parting plane divided into the connecting-rod main part 1 and connecting-rod KYAPU 2.
[0006] However, when it really fabricates with hot forging, using the steel (S45C, S48C equivalent steel, etc. of JIS) used conventionally as it is and divides into the connecting-rod main part 1 and connecting-rod KYAPU 2 in ordinary temperature after that, it becomes the so-called "ductility fracture surface" where the parting plane tore American and gum, and flat "brittle fracture appearance" is not obtained, but there is a problem that finishing plastic surgery processing by machining must be performed. Although a brittle fracture will arise and a flat brittle fracture appearance will be easily obtained if the above-mentioned division is performed at low temperature (for example, liquid nitrogen temperature), it is not technically easy to consider as a low-temperature state in the real operation line on which a lot of products flow, and since the costs which build and maintain a facility further increase, there is not necessarily a problem that it is not connected in cost reduction.
[0007] On the other hand, since cost increases, heat treatment after really fabricating with hot forging has also produced the request to the steel new type which can omit heat treatment.
[0008] As non-heat-treated steel which can omit the temper processing as heat treatment performed after hot rolling or hot forging, "non-temper high intensity steel" is proposed by JP,5-195140,A, for example. However, the non-heat-treated steel indicated by this official report is high intensity non-heat-treated steel of the type which prevented the crack produced on a bloom front face at the time of continuous casting. Therefore, when the above-mentioned proposal steel is used as the connecting-rod main part 1 and steel for connecting-rod KYAPU 2, to the method of

dividing into the connecting-rod main part 1 and connecting-rod KYAPU 2 in ordinary temperature, after really [said] fabricating, although desired intensity is obtained, ductility is too large and a brittle fracture appearance is not obtained. Therefore, it is necessary to perform finishing plastic surgery processing by machining.
[0009] Furthermore, recently, even when working an engine on severe conditions like sudden start, the request to non-heat-treated steel excellent in buckling strength is also large so that buckling may not be produced in a connecting rod.
[0010]
[Problem(s) to be Solved by the Invention] this invention was made in view of the above-mentioned present condition, and tensile strength offers a technical problem the high intensity and low ductility non-heat-treated steel with which it is steel and more than equivalent conventionally, and the fracture surface when dividing in ordinary temperature by method which really which carried out hot forging described forming material above presents a flat brittle fracture appearance. If it is in this invention, in addition to the aforementioned property, offer of non-heat-treated steel which has still higher buckling strength is also made a technical problem.
[0011]
[Means for Solving the Problem] this invention person acquired the following knowledge, as a result of repeating examination variously, in order to solve the above-mentioned technical problem.
[0012] ** the destructive gestalt in the ordinary temperature of the non-heat-treated steel which has a chemical composition in the specific condition range -- the following -- it has fn1, fn2, fn3, fn4 and fn5, and correlation And a brittle fracture is promoted when filling at least one of "fn 1>=0", "fn 2>=0", "fn 3>=0", "fn 4<=0", and "the fn(s) 5>=0." However, in addition, fn1=Si+2V-0.5, fn2=Si+2V+5P-0.8, fn3=N-0.1aluminum-0.002, fn4=N-0.3Ti, fn5=N-0.5aluminum-0.3Ti-0.15Nb-0.3V-1.3B-0.002, and the symbol of element in the formula of fn1 to fn5 express the content in weight % of the element.
[0013] ** When the elongation value of the steel materials when filling and carrying out the ordinary temperature tension test of at least one of above fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is 10% or less, the ordinary temperature parting plane of forming material really turns into a flat brittle fracture appearance which carried out hot forging.
[0014] ** Above ** (at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is filled) and the elongation value of the steel materials when carrying out an ordinary temperature tension test -- 10% or less -- in addition, the part which wants to really which carried out hot forging divide forming material, if notching of 0.5 or less mmRs is prepared in part at least Ordinary temperature division of forming material is really easily attained to the brittle fracture appearance [flat much more certainly] concerned by the parting plane only by applying few force.
[0015] ** the time of the chemical composition of steel being in the specific condition range -- the tensile strength of non-heat-treated steel -- the following -- it can arrange by fn6, and when this value is zero or more, the tensile strength of 800 or more MPas is obtained
[0016] The symbol of element in fn6=C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8, in addition fn6 also expresses the content in weight % of the element.
[0017] ** After controlling the chemical composition of steel strictly, if the conditions of elongation value <=10% of the steel materials when carrying out an ordinary temperature tension test to at least one of fn 1>=0 of the above-mentioned **, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 and **fn 6>=0 can be satisfied, it will become a flat brittle fracture appearance by division in ordinary temperature, and high intensity will be obtained. Therefore, the connecting-rod main part 1 and connecting-rod KYAPU 2 which have the tensile strength of 800 or more MPas which is request intensity according to said new process can be manufactured. in this case, the inside (the N section in drawing 1) of the large end hole which is the part which wants to divide the one fabrication material of ** -- if notching of 0.5 or less mmRs is prepared in part at least, the above-mentioned connecting-rod main part 1 and above-mentioned connecting-rod KYAPU 2 can be manufactured much more ease and certainly
[0018] ** In order to raise buckling strength, it is effective to raise the yield strength of steel.
[0019] ** If the steel which has a specific chemical composition fills fn 2>=0 indicated to the above-mentioned **, the brittle fracture of steel is not only promoted, but a yield ratio (yield strength/tensile strength) will increase, and 0.7 or more yield ratios will be obtained for non-heat-treated steel.
[0020] ** Therefore, after controlling the chemical composition of steel strictly, if the elongation value of the steel materials when carrying out an ordinary temperature tension test to fn 2>=0 can satisfy the conditions of 10% or less and fn 6>=0, while a high yield ratio will be obtained, it becomes a flat brittle fracture appearance by division in ordinary temperature, and high intensity is obtained. In this case, since tensile strength is 800 or more MPas, the high yield strength of 560 or more MPas will be obtained, and the connecting-rod main part 1 and connecting-rod

KYAPU 2 which were excellent also in buckling strength with said new process can be manufactured.
[0021] this invention based on the above-mentioned knowledge makes a summary the following high intensity and low ductility non-heat-treated steel.
[0022] "By weight %, C:0.20 - 0.70%, less than [Si:1.50%], Mn:0.30-2.00%, P:0.15% or less, S:0.10% or less, less than [Cu:0.20%], nickel: Less than [0.50%], Cr:0.02-2.00%, less than [Mo:0.50%], V:0.50% or less, less than [Nb:0.17%], less than [Ti:0.20%], B:0.0100% or less, less than [aluminum:0.100%], N:0.030% or less, the high intensity and low ductility non-heat-treated steel which contains less than [Pb:0.30%], the remainder consists of Fe and an unescapable impurity, and fills at least one of said fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0, and is further characterized by being fn 6>=0 "
[0023]
[Embodiments of the Invention] The reason which limits the chemical composition of the steel in this invention to below as mentioned above is explained. In addition, "%" means "weight %."
[0024] C: Although C is an element required to give desired static intensity to steel, it is also the element in which opposite side hot-working nature is reduced. In order to obtain minimum static intensity (they are 800 or more MPas at tensile strength), 0.20% or more is required. On the other hand, if it is made to contain exceeding 0.70%, the hot-working nature of steel may fall and a crack may be produced depending on a component system at the time of processing between heat. Therefore, the content of C was made into 0.20 - 0.70%. In addition, in order to secure the intensity (tensile strength and buckling strength) stabilized more, as for the content of C, considering as 0.25% or more is desirable. If C content is 0.30% or more, it is much more desirable.
[0025] It is not necessary to add Si:Si. If it adds, while promoting the deoxidation of steel, it also has the operation which raises hardenability. In order to acquire these effects certainly, as for Si, it is desirable to consider as 0.05% or more of content. However, if the content exceeds 1.50%, hot-working nature will fall extremely and will become easy to produce a crack at the time of processing between heat. Therefore, the content of Si was made into 1.50% or less. In addition, in order to secure much more stable hot-working nature, as for the upper limit of Si content, considering as 1.00% is desirable.
[0026] Mn:Mn has the operation which hardenability is raised [operation] and raises static intensity while it is required for deoxidation. However, since hot-working nature came to have deteriorated when the effect of a request of the content at less than 0.30% was not acquired but it exceeded 2.00%, the content was made into 0.30 - 2.00%.
[0027] P: It is not necessary to add P. Since there is an operation which a grain-boundary embrittlement is caused to and reduces ductility if it adds, it is effective in obtaining a flat brittle fracture appearance by the division method in ordinary temperature which was described above. In order to acquire this effect certainly, as for P, it is desirable to consider as 0.005% or more of content. However, if the content exceeds 0.15%, hot-working nature will deteriorate remarkably. Therefore, the content of P could be 0.15% or less. In addition, as for the content of P, considering as 0.10% or less is more desirable because of the stable hot-working nature reservation.
[0028] S: It is not necessary to also add S. Since there is an operation which a grain-boundary embrittlement is caused to and reduces ductility if it adds, it is effective in obtaining a flat brittle fracture appearance by the division method in ordinary temperature which was described above like P. Moreover, S has the operation which raises the cutting ability at the time of bolthole processing. In order to acquire these effects certainly, as for S, it is desirable to consider as 0.005% or more of content. However, if the content exceeds 0.10%, hot-working nature will deteriorate remarkably. Therefore, the upper limit of S content was made into 0.10%.
[0029] It is not necessary to add Cu:Cu. If it adds, it has the effect which raises hardenability and raises static intensity. In order to acquire this effect certainly, as for Cu, it is desirable to consider as 0.01% or more of content. However, if the content exceeds 0.20%, degradation of hot-working nature will be brought about and generating of a crack will be caused at the time of hot rolling and hot forging. Therefore, the content of Cu could be 0.20% or less.
[0030] It is not necessary to add nickel:nickel. If it adds, it has the effect which raises hardenability and raises static intensity. In order to acquire this effect certainly, as for nickel, it is desirable to consider as 0.01% or more of content. However, if the content exceeds 0.50%, the increase in ductility and toughness will be caused and a flat brittle fracture appearance will no longer be obtained. Therefore, the content of nickel was made into 0.50% or less.

[0031] Cr:Cr has the effect which hardenability is raised and raises static intensity. However, since the effect would be saturated, only cost would go up and economical efficiency would be spoiled even if the effect of a request of the content at less than 0.02% was not acquired but being contained exceeding 2.00%, the content was made into 0.02 - 2.00%. In addition, as for Cr content, considering as 0.10% or more is desirable.
[0032] It is not necessary to add Mo:Mo. If it adds, it has the effect which raises hardenability and raises intensity.

In order to acquire this effect certainly, as for Mo, it is desirable to consider as 0.01% or more of content. However, even if it makes it contain exceeding 0.50%, since it is saturated, only cost will go up and the aforementioned effect will spoil economical efficiency. Therefore, the content of Mo was made into 0.50% or less. In addition, as for Mo content, considering as 0.05% or more is much more desirable.

[0033] It is not necessary to also add V:V. If it adds, it has the effect which raises intensity. In order to acquire this effect certainly, as for V, it is desirable to consider as 0.005% or more of content. However, even if it makes it contain exceeding 0.50%, it is saturated, only cost goes up and the aforementioned effect spoils economical efficiency. Furthermore, degradation of hot-working nature is caused. Therefore, the content of V was made into 0.50% or less.

[0034] It is not necessary to add Nb:Nb. If it adds, it has the effect which raises intensity. In order to acquire this effect certainly, as for Nb, it is desirable to consider as 0.003% or more of content. However, even if it makes it contain exceeding 0.17%, it will be saturated, only cost will go up and the aforementioned effect will spoil economical efficiency. Furthermore, it comes to cause degradation of hot-working nature. Therefore, the content of Nb was made into 0.17% or less. In addition, in order to secure much more stable hot-working nature, it is desirable to make the upper limit of Nb content into 0.10%.

[0035] It is not necessary to also add Ti:Ti. If it adds, it has the effect which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected, and it has the effect which promotes a brittle fracture through the above fn4 and fn5. In order to acquire these effects certainly, as for Ti, it is desirable to consider as 0.005% or more of content. However, if it is made to contain exceeding 0.20%, it will come to cause degradation of hot-working nature. Therefore, the content of Ti was made into 0.20% or less.

[0036] B: It is not necessary to add B. If it adds, there is an effect which hardenability is raised and raises intensity. In order to acquire this effect certainly, as for B, it is desirable to consider as 0.0003% or more of content. However, if the content exceeds 0.0100%, about [that the improvement effect in hardenability is saturated] and hot-working nature will come to deteriorate remarkably. Therefore, the content of B was made into 0.0100% or less.

[0037] It is not necessary to add aluminum:aluminum. If it adds, while attaining stabilization and homogenization of the deoxidation of steel, a nitride is generated, crystal grain is turned minutely and it has the operation which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected, and it has the effect which promotes a brittle fracture through the above fn3 and fn5. In order to acquire these effects certainly, as for aluminum, it is desirable to consider as 0.005% or more of content. However, if it is made to contain exceeding 0.100%, it will come to cause degradation of hot-working nature. Therefore, the content of aluminum was made into 0.100% or less.

[0038] N: It is not necessary to make N contain. If it is made to contain, a nitride and a charcoal nitride are generated, crystal grain is turned minutely, and it has the operation which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected by the relation between Ti or aluminum, and when filling at least one of the above fn 3>=0, fn 4<=0, and the fn(s) 5>=0, it has the effect which promotes a brittle fracture. In order to acquire these effects certainly, as for N, it is desirable to consider as 0.0030% or more of content. However, since a dissolution raw material special to making N contain exceeding 0.030% in the ingot of steel generally, a facility, and technology are needed, cost may increase, economical efficiency may be spoiled and degradation of hot-working nature may be caused. Therefore, the content of N was made into 0.030% or less.

[0039] It is not necessary to make Pb:Pb contain. If it is made to contain, it has the effect which raises the cutting ability at the time of bolthole processing. In order to acquire this effect certainly, as for Pb, it is desirable to consider as 0.01% or more of content. However, if Pb is made to contain exceeding 0.30%, hot-working nature will deteriorate and generating of a crack will be caused at the time of hot rolling and hot forging. Therefore, the content of Pb was made into 0.30% or less.

[0040] The above fn1, fn2, fn3, fn4, and fn5 can arrange the destructive gestalt in the ordinary temperature of the non-heat-treated steel containing C of fn1, fn2, fn3, fn4, and 5:0.20% or more of fn(s), 0.30% or more of Mn, and 0.02% or more of Cr. A brittle fracture is promoted when filling at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0. And at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is filled. When the elongation value of the steel materials when carrying out an ordinary temperature tension test is 10% or less, according to and a new process which the ordinary temperature division fracture surface of forming material turns into a flat brittle fracture appearance which carried out hot forging, and was really described above The connecting-rod main part and connecting-rod KYAPU which have the tensile strength of 800 or more MPas which is request intensity can be manufactured. Therefore, it is specified that it fills at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0.

[0041] In addition, in fn 2>=0, 0.7 or more yield ratios are stabilized and they a brittle fracture is not only promoted, but are obtained. Therefore, when fn 2>=0 and the elongation value of the steel materials when carrying out an ordinary temperature tension test are 10% or less, the connecting-rod main part and connecting-rod KYAPU which have the tensile strength of 800 or more MPas also with high yield strength which were excellent also in buckling strength when putting in another way can be manufactured.
[0042] Especially the upper limit of the value of fn1 may be 2.0 of the upper limit which is not restricted and is calculated from fn1.
[0043] You may be 2.45 of the upper limit which especially the upper limit of the value of fn2 is not restricted, either, and is calculated from fn2.
[0044] Especially the upper limit of the value of fn3 may be 0.028 of the upper limit which is not restricted and is calculated from fn3.
[0045] You may be -0.06 of the lower limit which especially the minimum of the value of fn4 is not restricted, either and calculated from fn4.
[0046] You may be 0.028 of the upper limit which especially the upper limit of the value of fn5 is not restricted, either, and is calculated from fn5. In addition, it is set to fn3=fn5 in this case.
[0047] In addition, fn5 can be expressed as fn5=fn1- (0.4aluminum+0.3Ti+0.15Nb+0.3V+1.3B) using fn3. Therefore, in fn 5>=0, fn 3>=0 is also surely filled.
[0048] Moreover, fn5=fn4- (0.5aluminum+0.15Nb+0.3V+1.3B+0.002) and that come out and a certain shell, and fn 4<=0 and fn 5>=0 are materialized simultaneously do not have the relation of the above fn4 and fn5. From this, promotion of the brittle fracture in fn 4<=0 is considered to be a thing based on the so-called "free dissolution N" based on formation of the carbide of Ti, or a charcoal nitride for promotion of the brittle fracture in fn 5>=0 or fn 3>=0.
[0049] fn6: It begins, when the chemical composition of steel is controlled strictly and the value of the above fn6 is made or more into zero, and a connecting-rod main part and the tensile strength of 800 or more MPas required as connecting-rod KYAPU can be given to non-heat-treated steel. Therefore, it is referred to as fn 6>=0. You may be the maximum (value near 2.23) which especially a limit does not have in the upper limit of this value, and is calculated from fn6.
[0050] Bolthole processing is given to it after being ingoted by the usual method (for example, after the steel which has the above-mentioned chemical composition is really with which the connecting-rod main part 1 and connecting-rod KYAPU 2 were connected fabricated by the object with rolling and forging between the heat by the usual method). Then, it is divided in ordinary temperature by method which was described above to the connecting-rod main part 1 and connecting-rod KYAPU 2. In addition, there is also a thing inside the large end hole which is the part which is really [concerned] going to divide an object if needed (the N section in drawing 1) established for notching of 0.5 or less mmRs in part at least. Subsequently, with a bolt 3, it is combined with a crankshaft and the divided connecting-rod main part 1 and connecting-rod KYAPU 2 are assembled.
[0051]
[Example] The vacuum ingot of the steel which has the chemical composition shown in Tables 1-3 was carried out using test kiln by the usual method. The steel 1-34 in Tables 1 and 2 is this invention steel, and the steel 35-48 in Table 3 is the comparison steel from which either of the component separated from the range of the content specified by this invention.
[0052] Subsequently, after making such this invention steel and comparison steel with a slab by the usual method and heating at 1250 degrees C, hot forging was carried out to the round bar with a diameter of 30mm at the temperature of 1200-950 degrees C, and air cooling was carried out to ordinary temperature after that.
[0053] In this way, the JIS No. 4 test piece was cut down from the round bar with obtained hot forging, and the tension test was performed in ordinary temperature. Furthermore, the state of the fracture surface after an ordinary temperature tension test was observed with the scanning electron microscope (SEM).
[0054] In addition, the front face of the round bar which carried out hot forging to 30mm was observed visually, and checked the existence of a forging crack.
[0055] An ordinary temperature tension test result, a fracture surface observation result, and a forging-crack check result are shown in Tables 4 and 5.
[0056] Without each producing a forging crack, if it was in the steel 1-34 which is this invention steel, the desired tensile strength of 800 or more MPas and 10% or less of elongation were acquired, and all the fracture surface after an ordinary temperature tension test was flat brittle fracture appearances. What fills fn 2>=0 also among this invention steel has 0.7 or more yield ratios, and is understood that yield strength is high (above refer to Table 4).
[0057] On the other hand, in the amount of C, and the steel 35 and 48 from which fn6 separated from default value

to the low eye, respectively, tensile strength has not reached 800MPa(s) among the comparison steel from which either of the components separated from the range of the content specified by this invention.

[0058] Moreover, the forging crack between heat was accepted in the steel 36-39 and steel 41-46 from which the amount of Si, the amount of Mn, the amount of P, the amount of S, the amount of V, the amount of Nb(s), the amount of Ti, the amount of B, the amount of aluminum, and the amount of Pb(s) separated high to default value, respectively.

[0059] In the steel 40 from which the amount of nickel separated more highly to the default value of this invention, ordinary temperature elongation exceeded 10%, and the fracture surface after an ordinary temperature tension test was a ductile fracture.

[0060] In order that it might separate from the conditions which the value of the above fn1-fn5 specified by this invention in steel 47 and ordinary temperature elongation might exceed 10%, the fracture surface after an ordinary temperature tension test was a ductile fracture (above refer to Table 5).

[0061] Subsequently, it really with which the connecting-rod main part 1 and connecting-rod KYAPU 2 were connected by the usual hot-forging method by being made from the steel 5, 16, 31, and 34 which is this invention steel indicated to the aforementioned table 1 carried out hot forming of the object 20 bodies at a time respectively. In addition, notching of 0.3mmR(s) was attached to the N section of drawing 1 after hot forming every five of 20 bodies. Subsequently, the division test to the connecting-rod main part 1 and connecting-rod KYAPU 2 was performed in ordinary temperature by said method. Consequently, it turns out that a flat brittle fracture appearance is obtained by all 20 bodies, and each steel can be used without the finishing plastic surgery by machining for them. In addition, especially division of each five steel which attached notching was easy.

[0062]

[Table 1]

[0063]
[Table 2]

表　1

区分	鋼種	化学組成（重量%）													残部：Feおよび不純物							
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	1	0.32	0.70	1.19	0.071	0.049	0.02	0.01	0.22	0.01	0.25	-	-	-	0.028	0.0058	0.13	0.70	0.76	0.0010	* 0.0058	*-0.0852	0.2555
	2	0.51	0.38	0.37	0.056	0.042	0.06	0.05	0.18	0.08	0.11	0.025	0.121	0.0031	0.067	0.0152	0.30	0.10	0.08	0.0570	-0.0211	*-0.0974	0.0144
	3	0.54	0.64	0.77	0.072	0.024	0.05	-	0.36	0.16	0.24	0.003	0.093	0.0005	0.025	0.0049	0.11	0.62	0.68	0.0004	-0.0230	*-0.1106	0.4187
	4	0.20	0.68	1.27	0.046	0.056	-	-	0.27	-	0.29	-	0.002	-	0.031	-	-	0.76	0.69	*-0.0051	-0.0006	*-0.1051	0.2219
	5	0.55	0.58	0.49	0.002	0.044	-	0.04	0.25	0.12	0.05	0.011	-	-	0.073	0.0063	0.15	0.18	*-0.11	*-0.0030	* 0.0063	*-0.0489	0.0139
	6	0.33	0.11	0.81	0.063	0.038	0.11	-	0.48	0.46	0.36	0.006	0.084	0.0013	0.097	0.0056	0.18	0.33	0.35	*-0.0061	-0.0196	*-0.1807	0.3789
	7	0.48	0.72	1.46	0.148	0.041	0.08	0.11	0.86	0.05	0.11	0.091	-	-	0.029	0.0061	-	0.44	0.88	0.0012	* 0.0061	*-0.0571	0.3917
	8	0.37	0.57	1.98	0.057	0.054	-	0.48	0.33	-	0.25	-	0.110	0.0024	0.081	0.0033	0.01	0.57	0.56	*-0.0068	-0.0297	*-0.1503	0.4719
	9	0.64	1.47	0.96	0.084	0.046	0.12	-	0.56	0.24	0.08	0.157	-	-	-	0.0063	0.11	1.13	1.25	0.0043	* 0.0063	*-0.0433	0.4054
	10	0.35	0.81	0.56	0.021	0.053	0.19	0.09	0.19	0.11	0.37	-	0.012	-	0.033	-	0.16	1.05	0.86	*-0.0053	-0.0038	*-0.1331	0.3588
	11	0.31	0.18	0.36	0.078	0.081	0.01	-	1.95	0.09	0.26	0.008	0.157	0.0024	0.005	0.0046	-	0.20	0.29	0.0021	-0.0425	*-0.1293	0.4143
	12	0.29	1.20	0.30	0.103	0.011	-	0.20	0.28	-	0.49	-	-	-	0.018	0.0124	0.02	1.68	1.90	0.0086	* 0.0124	*-0.1456	0.5342
	13	0.31	0.74	1.24	0.037	0.047	0.03	0.08	0.68	0.38	0.22	-	0.021	0.0083	0.046	0.0098	0.29	0.68	0.57	0.0032	* 0.0035	*-0.0983	0.3160
	14	0.41	0.27	0.68	0.075	0.096	0.07	0.12	1.24	-	0.18	0.011	-	-	0.024	0.0052	0.14	0.13	0.21	0.0008	* 0.0052	*-0.0645	0.2832
	15	0.30	1.04	0.56	0.048	0.063	-	0.05	0.25	0.02	0.36	0.005	0.118	0.0026	0.059	0.0195	0.17	1.26	1.20	0.0116	-0.0159	*-0.1595	0.3218
	16	0.70	0.16	0.82	0.019	0.007	0.01	0.01	0.04	0.05	-	-	-	-	0.028	0.0060	0.01	*-0.34	*-0.55	0.0012	* 0.0060	*-0.0100	0.0841
	17	0.69	0.16	0.66	0.009	0.063	-	0.03	0.12	-	-	-	-	-	0.004	0.0120	-	*-0.34	*-0.60	0.0096	* 0.0120	0.0080	0.0203

fn1=Si+2V−0.5、　fn2=Si+2V+5P−0.8

fn3=N−0.1Al−0.002、　fn4=N−0.3Ti

fn5=N−0.5Al−0.3Ti−0.15Nb−0.3V−1.3B−0.002

fn6=C+ (Si／10) + (Mn／5) + (5Cr／22) +1.65V− (5S／7) −0.8

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0064]
[Table 3]

表　2

区分	鋼種	化学組成（重量%）																残部：Feおよび不純物					
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	18	0.35	0.70	1.19	0.070	0.049	-	-	0.19	-	0.24	-	0.003	-	0.030	0.0118	0.16	0.68	0.73	0.0068	* 0.0109	*-0.0781	0.2622
	19	0.63	0.22	0.52	0.015	0.015	0.04	-	0.65	0.01	-	0.005	-	-	-	0.0040	-	*-0.28	*-0.51	0.0020	* 0.0040	0.0013	0.0930
	20	0.49	0.50	0.90	0.015	0.055	-	-	0.14	0.03	0.06	-	-	-	0.019	0.0050	0.08	0.12	*-0.11	0.0011	* 0.0050	*-0.0245	0.0115
	21	0.50	0.25	0.90	0.015	0.057	0.05	-	0.13	-	0.12	-	-	-	0.031	0.0070	-	*-0.01	*-0.24	0.0019	* 0.0070	*-0.0465	0.0918
	22	0.53	0.25	0.95	0.017	0.017	0.11	0.03	0.03	0.04	0.10	-	-	-	0.029	0.0075	-	*-0.05	*-0.27	0.0026	* 0.0025	*-0.0390	0.1047
	23	0.32	0.70	1.17	0.069	0.050	-	0.06	0.19	0.01	0.15	0.003	-	-	0.025	0.0100	0.15	0.50	0.55	0.0055	* 0.0100	*-0.0500	0.0790
	24	0.31	0.70	0.78	0.074	0.048	-	-	0.20	-	0.20	-	-	-	0.031	0.0088	0.14	0.60	0.67	0.0037	* 0.0088	*-0.0687	0.0772
	25	0.68	0.31	1.95	0.005	0.095	-	0.24	0.03	0.36	-	-	-	-	0.097	0.0154	-	*-0.19	*-0.47	0.0037	* 0.0154	*-0.0351	0.2400
	26	0.35	0.29	0.48	0.047	-	0.01	-	1.90	0.07	0.01	-	0.018	-	0.014	0.0178	-	*-0.19	*-0.26	0.0144	* 0.0124	0.0004	0.1233
	27	0.31	0.99	1.86	0.073	0.018	0.06	-	0.25	0.24	-	0.004	-	-	0.030	0.0199	0.05	0.49	0.31	0.0149	* 0.0199	0.0023	0.0250
	28	0.63	0.05	0.95	0.018	0.036	-	0.08	0.63	0.42	-	-	0.061	-	-	0.0050	0.08	*-0.45	*-0.66	0.0030	-0.0133	*-0.0153	0.1425
	29	0.37	0.99	1.54	0.015	-	0.08	-	0.51	0.14	0.02	0.011	0.053	0.0006	0.006	0.0125	0.12	0.53	0.31	0.0099	-0.0034	*-0.0168	0.1259
	30	0.67	0.11	0.96	0.073	0.018	0.06	-	0.25	0.24	-	0.004	0.074	-	0.030	0.0124	0.05	*-0.39	*-0.33	0.0074	-0.0098	*-0.0274	0.1170
	31	0.30	0.38	0.95	0.056	0.034	0.16	0.09	1.77	0.11	0.01	0.005	0.108	0.0007	0.098	0.0115	-	*-0.10	*-0.12	*-0.0003	-0.0209	*-0.0766	0.1225
	32	0.35	0.70	1.18	0.056	0.016	-	0.46	1.37	0.07	-	-	0.061	-	0.048	0.0085	-	0.20	0.18	0.0017	-0.0098	*-0.0358	0.1559
	33	0.52	0.29	1.95	0.008	-	-	-	0.74	0.29	-	-	0.095	0.0004	-	0.0097	0.15	*-0.21	*-0.47	0.0077	-0.0188	*-0.0213	0.3072
	34	0.54	0.46	1.43	0.097	-	0.19	-	0.86	0.11	-	0.098	0.003	-	0.099	0.0078	-	*-0.04	0.15	*-0.0041	* 0.0069	*-0.0593	0.2675

$fn1 = Si + 2V - 0.5$、　$fn2 = Si + 2V + 5P - 0.8$

$fn3 = N - 0.1Al - 0.002$、　$fn4 = N - 0.3Ti$

$fn5 = N - 0.5Al - 0.3Ti - 0.15Nb - 0.3V - 1.3B - 0.002$

$fn6 = C + (Si/10) + (Mn/5) + (5Cr/22) + 1.65V - (5S/7) - 0.8$

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0065]
[Table 4]

表　3

区分	鋼種	化学組成（重量%）残部：Feおよび不純物																				
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
比較鋼	35	*0.18	0.68	0.85	0.055	0.051	-	-	0.05	-	0.30	-	0.003	-	0.025	0.0055	-	0.78	0.76	0.0010	* 0.0046	*-0.0999	0.0879
	36	0.64	*1.57	0.96	0.084	0.046	0.12	-	0.56	0.20	0.07	-	-	-	-	0.0066	0.11	1.21	1.33	0.0046	* 0.0068	*-0.0164	0.3989
	37	0.67	0.35	*2.09	0.005	0.081	-	0.08	0.05	0.35	-	-	-	-	0.084	0.0154	-	*-0.15	*-0.43	0.0050	* 0.0154	*-0.0286	0.2765
	38	0.50	0.73	1.46	*0.159	0.042	0.08	-	0.85	-	0.11	0.090	-	-	0.029	0.0060	-	0.45	0.95	0.0011	* 0.0060	*-0.0570	0.4097
	39	0.42	0.28	0.69	0.075	*0.108	0.07	0.11	1.25	-	0.18	0.011	-	-	0.024	0.0055	0.14	0.14	0.22	0.0011	* 0.0055	*-0.0642	0.2899
	40	0.38	0.58	1.95	0.056	0.055	-	*0.55	0.35	-	0.25	-	0.090	0.0024	0.080	0.0033	0.05	0.58	0.56	*-0.0067	-0.0237	*-0.1438	0.4808
	41	0.31	1.18	0.30	0.105	0.081	-	0.20	0.25	0.05	*0.53	-	-	-	0.019	0.0125	0.02	1.74	1.97	0.0086	* 0.0125	*-0.1580	0.5615
	42	0.65	1.40	0.95	0.084	0.089	0.12	-	0.56	0.24	0.08	*0.188	-	-	-	0.0075	-	1.06	1.18	0.0055	* 0.0075	*-0.0467	0.3757
	43	0.32	0.18	0.36	0.078	0.082	-	-	1.90	-	0.27	0.005	*0.245	-	0.010	0.0049	0.15	0.22	0.31	0.0019	-0.0686	*-0.1574	0.4287
	44	0.35	0.74	1.25	0.038	0.045	0.03	-	0.71	0.11	0.21	-	0.021	*0.0109	0.051	0.0105	-	0.66	0.55	0.0034	* 0.0042	*-0.1005	0.3497
	45	0.33	0.10	0.75	0.056	0.041	0.12	-	0.55	-	0.37	-	-	-	*0.105	0.0059	-	0.34	0.32	*-0.0066	* 0.0059	*-0.1596	0.3962
	46	0.41	0.27	0.70	0.072	0.095	0.07	0.12	1.23	-	0.18	-	-	-	0.025	0.0056	*0.34	0.13	0.19	0.0011	* 0.0056	*-0.0629	0.2857
	47	0.55	0.29	1.25	0.012	0.086	-	-	0.58	-	-	-	-	-	0.060	0.0051	-	*-0.21	*-0.45	*-0.0029	* 0.0051	*-0.0269	0.0994
	48	0.51	0.64	0.83	0.062	0.015	0.05	0.03	0.24	-	-	-	-	-	0.025	0.0068	-	0.14	0.15	0.0023	* 0.0068	*-0.0077	*-0.0162

$fn1=Si+2V-0.5$、　$fn2=Si+2V+5P-0.8$

$fn3=N-0.1Al-0.002$、　$fn4=N-0.3Ti$

$fn5=N-0.5Al-0.3Ti-0.15Nb-0.3V-1.3B-0.002$

$fn6=C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8$

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

表 4

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
本発明鋼	1	836	1058	0.79	7	脆性	無
	2	812	816	0.75	10	脆性	無
	3	902	1219	0.74	5	脆性	無
	4	830	1037	0.80	8	脆性	無
	5	533	820	0.65	10	脆性	無
	6	914	1187	0.77	7	脆性	無
	7	884	1195	0.74	7	脆性	無
	8	955	1224	0.78	6	脆性	無
	9	858	1208	0.71	6	脆性	無
	10	906	1162	0.78	7	脆性	無
	11	939	1219	0.77	6	脆性	無
	12	1042	1336	0.78	5	脆性	無
	13	877	1124	0.78	6	脆性	無
	14	814	1085	0.75	7	脆性	無
	15	862	1120	0.77	7	脆性	無
	16	505	886	0.57	9	脆性	無
	17	420	824	0.51	10	脆性	無
本発明鋼	18	809	1065	0.76	8	脆性	無
	19	510	895	0.57	9	脆性	無
	20	548	818	0.67	10	脆性	無
	21	582	895	0.65	9	脆性	無
	22	580	907	0.64	9	脆性	無
	23	681	884	0.77	10	脆性	無
	24	681	873	0.78	10	脆性	無
	25	641	1051	0.61	9	脆性	無
	26	608	936	0.65	8	脆性	無
	27	640	831	0.77	10	脆性	無
	28	472	943	0.50	8	脆性	無
	29	731	937	0.78	8	脆性	無
	30	545	924	0.59	9	脆性	無
	31	602	926	0.65	9	脆性	無
	32	752	964	0.78	9	脆性	無
	33	678	1112	0.61	7	脆性	無
	34	805	1073	0.75	8	脆性	無

[0066]
[Table 5]

表 5

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
比較鋼	35	642	792	0.81	10	脆性	無
	36	837	1195	0.70	7	脆性	有
	37	639	1083	0.59	8	脆性	有
	38	871	1210	0.72	6	脆性	有
	39	820	1093	0.75	10	脆性	有
	40	999	1281	0.78	12	延性	無
	41	1065	1366	0.78	5	脆性	有
	42	842	1170	0.72	7	脆性	有
	43	943	1225	0.77	6	脆性	有
	44	1026	1350	0.76	5	脆性	有
	45	920	1195	0.77	7	脆性	有
	46	817	1089	0.75	8	脆性	有
	47	537	895	0.60	29	延性	無
	48	597	796	0.75	10	脆性	無

[0067]
[Effect of the Invention] If the high intensity and low ductility non-heat-treated steel by this invention are used, it is possible to manufacture a connecting-rod main part and connecting-rod KYAPU in the low new process of cost, and the effect on industry is large.

[Translation done.]

* NOTICES *

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2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL FIELD

[The technical field to which invention belongs] Although, as for this invention, high intensity is required in more detail about high intensity and low ductility non-heat-treated steel, rather, it is not needed, but cold division processing in ordinary temperature is possible for ductility, the fracture surface presents a flat brittle fracture appearance, and it is related with high intensity and low ductility non-heat-treated steel suitable as a material connecting rods, such as an automobile engine, and for connecting-rod caps.

[Translation done.]

PRIOR ART

[Description of the Prior Art] joint - After hot forging of the main part 1 and connecting-rod KYAPU (common-name connecting rod cap) 2 of a connecting rod (common-name connecting rod) which are shown in drawing 1 which is parts, such as an automobile engine, was conventionally carried out at another process, temper processing of hardening annealing was performed to them, and subsequently, they finished with processing of the bolthole by machining, received plastic surgery processing, and were assembled with the bolt 3 after that by the crankshaft with a complicated configuration.

[0003] However, the movement of manufacturing-cost reduction of various autoparts is activating recently reflecting the severe economic situation, and this movement is no longer an exception also in engine parts.

[0004] For this reason, about the aforementioned connecting-rod main part 1 and aforementioned connecting-rod KYAPU 2, both are really fabricated with hot forging, and hardening annealing is heat-treated to this as a cure against manufacturing-cost reduction, or it cools radiationally after hot forging, and divides into the connecting-rod main part 1 and connecting-rod KYAPU 2 after that, and the method of combining with a crankshaft and assembling machining for the finishing plastic surgery to a joint (planes of composition) with a bolt 3, without giving, is examined. By this method, before processing of a bolthole divides the aforementioned one fabrication material, it is performed behind.

[0005] How to give and divide the force committed in the direction shown by the arrow in drawing 1 by inserting a fixture, for example as a method of dividing the really [above-mentioned] fabricated connecting-rod main part 1 and connecting-rod KYAPU 2 can be considered. By this method, it becomes very important to make into a flat the parting plane divided into the connecting-rod main part 1 and connecting-rod KYAPU 2.

[0006] However, when it really fabricates with hot forging, using the steel (S45C, S48C equivalent steel, etc. of JIS) used conventionally as it is and divides into the connecting-rod main part 1 and connecting-rod KYAPU 2 in ordinary temperature after that, it becomes the so-called "ductility fracture surface" where the parting plane tore American and gum, and flat "brittle fracture appearance" is not obtained, but there is a problem that finishing plastic surgery processing by machining must be performed. Although a brittle fracture will arise and a flat brittle fracture appearance will be easily obtained if the above-mentioned division is performed at low temperature (for example, liquid nitrogen temperature), it is not technically easy to consider as a low-temperature state in the real operation line on which a lot of products flow, and since the costs which build and maintain a facility further increase, there is not necessarily a problem that it is not connected in cost reduction.

[0007] On the other hand, since cost increases, heat treatment after really fabricating with hot forging has also produced the request to the steel new type which can omit heat treatment.

[0008] As non-heat-treated steel which can omit the temper processing as heat treatment performed after hot rolling or hot forging, "non-temper high intensity steel" is proposed by JP,5-195140,A, for example. However, the non-heat-treated steel indicated by this official report is high intensity non-heat-treated steel of the type which prevented the crack produced on a bloom front face at the time of continuous casting. Therefore, when the above-mentioned proposal steel is used as the connecting-rod main part 1 and steel for connecting-rod KYAPU 2, to the method of dividing into the connecting-rod main part 1 and connecting-rod KYAPU 2 in ordinary temperature, after really [said] fabricating, although desired intensity is obtained, ductility is too large and a brittle fracture appearance is not obtained. Therefore, it is necessary to perform finishing plastic surgery processing by machining.

[0009] Furthermore, recently, even when working an engine on severe conditions like sudden start, the request to non-heat-treated steel excellent in buckling strength is also large so that buckling may not be produced in a connecting rod.

* NOTICES *

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3.In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] If the high intensity and low ductility non-heat-treated steel by this invention are used, it is possible to manufacture a connecting-rod main part and connecting-rod KYAPU in the low new process of cost, and the effect on industry is large.

[Translation done.]

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2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] this invention was made in view of the above-mentioned present condition, and tensile strength offers a technical problem the high intensity and low ductility non-heat-treated steel with which it is steel and more than equivalent conventionally, and the fracture surface when dividing in ordinary temperature by method which really which carried out hot forging described forming material above presents a flat brittle fracture appearance. If it is in this invention, in addition to the aforementioned property, offer of non-heat-treated steel which has still higher buckling strength is also made a technical problem.

[Translation done.]

MEANS

[Means for Solving the Problem] this invention person acquired the following knowledge, as a result of repeating examination variously, in order to solve the above-mentioned technical problem.
[0012] ** the destructive gestalt in the ordinary temperature of the non-heat-treated steel which has a chemical composition in the specific condition range -- the following -- it has fn1, fn2, fn3, fn4 and fn5, and correlation And a brittle fracture is promoted when filling at least one of "fn 1>=0", "fn 2>=0", "fn 3>=0", "fn 4<=0", and "the fn(s) 5>=0." However, in addition, fn1=Si+2V-0.5, fn2=Si+2V+5P-0.8, fn3=N-0.1aluminum-0.002, fn4=N-0.3Ti, fn5=N-0.5aluminum-0.3Ti-0.15Nb-0.3V-1.3B-0.002, and the symbol of element in the formula of fn1 to fn5 express the content in weight % of the element.
[0013] ** When the elongation value of the steel materials when filling and carrying out the ordinary temperature tension test of at least one of above fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is 10% or less, the ordinary temperature parting plane of forming material really turns into a flat brittle fracture appearance which carried out hot forging.
[0014] ** Above ** (at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is filled) and the elongation value of the steel materials when carrying out an ordinary temperature tension test -- 10% or less -- in addition, the part which wants to really which carried out hot forging divide forming material, if notching of 0.5 or less mmRs is prepared in part at least Ordinary temperature division of forming material is really easily attained to the brittle fracture appearance [flat much more certainly] concerned by the parting plane only by applying few force.
[0015] ** the time of the chemical composition of steel being in the specific condition range -- the tensile strength of non-heat-treated steel -- the following -- it can arrange by fn6, and when this value is zero or more, the tensile strength of 800 or more MPas is obtained
[0016] The symbol of element in fn6=C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8, in addition fn6 also expresses the content in weight % of the element.
[0017] ** After controlling the chemical composition of steel strictly, if the conditions of elongation value <=10% of the steel materials when carrying out an ordinary temperature tension test to at least one of fn 1>=0 of the above-mentioned **, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 and **fn 6>=0 can be satisfied, it will become a flat brittle fracture appearance by division in ordinary temperature, and high intensity will be obtained. Therefore, the connecting-rod main part 1 and connecting-rod KYAPU 2 which have the tensile strength of 800 or more MPas which is request intensity according to said new process can be manufactured. in this case, the inside (the N section in drawing 1) of the large end hole which is the part which wants to divide the one fabrication material of ** -- if notching of 0.5 or less mmRs is prepared in part at least, the above-mentioned connecting-rod main part 1 and above-mentioned connecting-rod KYAPU 2 can be manufactured much more ease and certainly
[0018] ** In order to raise buckling strength, it is effective to raise the yield strength of steel.
[0019] ** If the steel which has a specific chemical composition fills fn 2>=0 indicated to the above-mentioned **, the brittle fracture of steel is not only promoted, but a yield ratio (yield strength/tensile strength) will increase, and 0.7 or more yield ratios will be obtained for non-heat-treated steel.
[0020] ** Therefore, after controlling the chemical composition of steel strictly, if the elongation value of the steel materials when carrying out an ordinary temperature tension test to fn 2>=0 can satisfy the conditions of 10% or less and fn 6>=0, while a high yield ratio will be obtained, it becomes a flat brittle fracture appearance by division in ordinary temperature, and high intensity is obtained. In this case, since tensile strength is 800 or more MPas, the high yield strength of 560 or more MPas will be obtained, and the connecting-rod main part 1 and connecting-rod KYAPU 2 which were excellent also in buckling strength with said new process can be manufactured.
[0021] this invention based on the above-mentioned knowledge makes a summary the following high intensity and

low ductility non-heat-treated steel.
[0022] "By weight %, C:0.20 - 0.70%, less than [Si:1.50%], Mn:0.30-2.00%, P:0.15% or less, S:0.10% or less, less than [Cu:0.20%], nickel: Less than [0.50%], Cr:0.02-2.00%, less than [Mo:0.50%], V:0.50% or less, less than [Nb:0.17%], less than [Ti:0.20%], B:0.0100% or less, less than [aluminum:0.100%], N:0.030% or less, the high intensity and low ductility non-heat-treated steel which contains less than [Pb:0.30%], the remainder consists of Fe and an unescapable impurity, and fills at least one of said fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0, and is further characterized by being fn 6>=0 "
[0023]
[Embodiments of the Invention] The reason which limits the chemical composition of the steel in this invention to below as mentioned above is explained. In addition, "%" means "weight %."
[0024] C: Although C is an element required to give desired static intensity to steel, it is also the element in which opposite side hot-working nature is reduced. In order to obtain minimum static intensity (they are 800 or more MPas at tensile strength), 0.20% or more is required. On the other hand, if it is made to contain exceeding 0.70%, the hot-working nature of steel may fall and a crack may be produced depending on a component system at the time of processing between heat. Therefore, the content of C was made into 0.20 - 0.70%. In addition, in order to secure the intensity (tensile strength and buckling strength) stabilized more, as for the content of C, considering as 0.25% or more is desirable. If C content is 0.30% or more, it is much more desirable.
[0025] It is not necessary to add Si:Si. If it adds, while promoting the deoxidation of steel, it also has the operation which raises hardenability. In order to acquire these effects certainly, as for Si, it is desirable to consider as 0.05% or more of content. However, if the content exceeds 1.50%, hot-working nature will fall extremely and will become easy to produce a crack at the time of processing between heat. Therefore, the content of Si was made into 1.50% or less. In addition, in order to secure much more stable hot-working nature, as for the upper limit of Si content, considering as 1.00% is desirable.
[0026] Mn:Mn has the operation which hardenability is raised [operation] and raises static intensity while it is required for deoxidation. However, since hot-working nature came to have deteriorated when the effect of a request of the content at less than 0.30% was not acquired but it exceeded 2.00%, the content was made into 0.30 - 2.00%.
[0027] P: It is not necessary to add P. Since there is an operation which a grain-boundary embrittlement is caused to and reduces ductility if it adds, it is effective in obtaining a flat brittle fracture appearance by the division method in ordinary temperature which was described above. In order to acquire this effect certainly, as for P, it is desirable to consider as 0.005% or more of content. However, if the content exceeds 0.15%, hot-working nature will deteriorate remarkably. Therefore, the content of P could be 0.15% or less. In addition, as for the content of P, considering as 0.10% or less is more desirable because of the stable hot-working nature reservation.
[0028] S: It is not necessary to also add S. Since there is an operation which a grain-boundary embrittlement is caused to and reduces ductility if it adds, it is effective in obtaining a flat brittle fracture appearance by the division method in ordinary temperature which was described above like P. Moreover, S has the operation which raises the cutting ability at the time of bolthole processing. In order to acquire these effects certainly, as for S, it is desirable to consider as 0.005% or more of content. However, if the content exceeds 0.10%, hot-working nature will deteriorate remarkably. Therefore, the upper limit of S content was made into 0.10%.
[0029] It is not necessary to add Cu:Cu. If it adds, it has the effect which raises hardenability and raises static intensity. In order to acquire this effect certainly, as for Cu, it is desirable to consider as 0.01% or more of content. However, if the content exceeds 0.20%, degradation of hot-working nature will be brought about and generating of a crack will be caused at the time of hot rolling and hot forging. Therefore, the content of Cu could be 0.20% or less.
[0030] It is not necessary to add nickel:nickel. If it adds, it has the effect which raises hardenability and raises static intensity. In order to acquire this effect certainly, as for nickel, it is desirable to consider as 0.01% or more of content. However, if the content exceeds 0.50%, the increase in ductility and toughness will be caused and a flat brittle fracture appearance will no longer be obtained. Therefore, the content of nickel was made into 0.50% or less.

[0031] Cr:Cr has the effect which hardenability is raised and raises static intensity. However, since the effect would be saturated, only cost would go up and economical efficiency would be spoiled even if the effect of a request of the content at less than 0.02% was not acquired but being contained exceeding 2.00%, the content was made into 0.02 - 2.00%. In addition, as for Cr content, considering as 0.10% or more is desirable.
[0032] It is not necessary to add Mo:Mo. If it adds, it has the effect which raises hardenability and raises intensity. In order to acquire this effect certainly, as for Mo, it is desirable to consider as 0.01% or more of content. However, even if it makes it contain exceeding 0.50%, since it is saturated, only cost will go up and the aforementioned effect

will spoil economical efficiency. Therefore, the content of Mo was made into 0.50% or less. In addition, as for Mo content, considering as 0.05% or more is much more desirable.

[0033] It is not necessary to also add V:V. If it adds, it has the effect which raises intensity. In order to acquire this effect certainly, as for V, it is desirable to consider as 0.005% or more of content. However, even if it makes it contain exceeding 0.50%, it is saturated, only cost goes up and the aforementioned effect spoils economical efficiency. Furthermore, degradation of hot-working nature is caused. Therefore, the content of V was made into 0.50% or less.

[0034] It is not necessary to add Nb:Nb. If it adds, it has the effect which raises intensity. In order to acquire this effect certainly, as for Nb, it is desirable to consider as 0.003% or more of content. However, even if it makes it contain exceeding 0.17%, it will be saturated, only cost will go up and the aforementioned effect will spoil economical efficiency. Furthermore, it comes to cause degradation of hot-working nature. Therefore, the content of Nb was made into 0.17% or less. In addition, in order to secure much more stable hot-working nature, it is desirable to make the upper limit of Nb content into 0.10%.

[0035] It is not necessary to also add Ti:Ti. If it adds, it has the effect which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected, and it has the effect which promotes a brittle fracture through the above fn4 and fn5. In order to acquire these effects certainly, as for Ti, it is desirable to consider as 0.005% or more of content. However, if it is made to contain exceeding 0.20%, it will come to cause degradation of hot-working nature. Therefore, the content of Ti was made into 0.20% or less.

[0036] B: It is not necessary to add B. If it adds, there is an effect which hardenability is raised and raises intensity. In order to acquire this effect certainly, as for B, it is desirable to consider as 0.0003% or more of content. However, if the content exceeds 0.0100%, about [that the improvement effect in hardenability is saturated] and hot-working nature will come to deteriorate remarkably. Therefore, the content of B was made into 0.0100% or less.

[0037] It is not necessary to add aluminum:aluminum. If it adds, while attaining stabilization and homogenization of the deoxidation of steel, a nitride is generated, crystal grain is turned minutely and it has the operation which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected, and it has the effect which promotes a brittle fracture through the above fn3 and fn5. In order to acquire these effects certainly, as for aluminum, it is desirable to consider as 0.005% or more of content. However, if it is made to contain exceeding 0.100%, it will come to cause degradation of hot-working nature. Therefore, the content of aluminum was made into 0.100% or less.

[0038] N: It is not necessary to make N contain. If it is made to contain, a nitride and a charcoal nitride are generated, crystal grain is turned minutely, and it has the operation which raises intensity. Moreover, the destructive gestalt in the ordinary temperature of non-heat-treated steel is affected by the relation between Ti or aluminum, and when filling at least one of the above fn 3>=0, fn 4<=0, and the fn(s) 5>=0, it has the effect which promotes a brittle fracture. In order to acquire these effects certainly, as for N, it is desirable to consider as 0.0030% or more of content. However, since a dissolution raw material special to making N contain exceeding 0.030% in the ingot of steel generally, a facility, and technology are needed, cost may increase, economical efficiency may be spoiled and degradation of hot-working nature may be caused. Therefore, the content of N was made into 0.030% or less.

[0039] It is not necessary to make Pb:Pb contain. If it is made to contain, it has the effect which raises the cutting ability at the time of bolthole processing. In order to acquire this effect certainly, as for Pb, it is desirable to consider as 0.01% or more of content. However, if Pb is made to contain exceeding 0.30%, hot-working nature will deteriorate and generating of a crack will be caused at the time of hot rolling and hot forging. Therefore, the content of Pb was made into 0.30% or less.

[0040] The above fn1, fn2, fn3, fn4, and fn5 can arrange the destructive gestalt in the ordinary temperature of the non-heat-treated steel containing C of fn1, fn2, fn3, fn4, and 5:0.20% or more of fn(s), 0.30% or more of Mn, and 0.02% or more of Cr. A brittle fracture is promoted when filling at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0. And at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0 is filled. When the elongation value of the steel materials when carrying out an ordinary temperature tension test is 10% or less, according to and a new process which the ordinary temperature division fracture surface of forming material turns into a flat brittle fracture appearance which carried out hot forging, and was really described above The connecting-rod main part and connecting-rod KYAPU which have the tensile strength of 800 or more MPas which is request intensity can be manufactured. Therefore, it is specified that it fills at least one of fn 1>=0, fn 2>=0, fn 3>=0, fn 4<=0, and the fn(s) 5>=0.

[0041] In addition, in fn 2>=0, 0.7 or more yield ratios are stabilized and they a brittle fracture is not only promoted, but are obtained. Therefore, when fn 2>=0 and the elongation value of the steel materials when carrying

out an ordinary temperature tension test are 10% or less, the connecting-rod main part and connecting-rod KYAPU which have the tensile strength of 800 or more MPas also with high yield strength which were excellent also in buckling strength when putting in another way can be manufactured.

[0042] Especially the upper limit of the value of fn1 may be 2.0 of the upper limit which is not restricted and is calculated from fn1.

[0043] You may be 2.45 of the upper limit which especially the upper limit of the value of fn2 is not restricted, either, and is calculated from fn2.

[0044] Especially the upper limit of the value of fn3 may be 0.028 of the upper limit which is not restricted and is calculated from fn3.

[0045] You may be -0.06 of the lower limit which especially the minimum of the value of fn4 is not restricted, either and calculated from fn4.

[0046] You may be 0.028 of the upper limit which especially the upper limit of the value of fn5 is not restricted, either, and is calculated from fn5. In addition, it is set to fn3=fn5 in this case.

[0047] In addition, fn5 can be expressed as fn5=fn1- (0.4aluminum+0.3Ti+0.15Nb+0.3V+1.3B) using fn3. Therefore, in fn 5>=0, fn 3>=0 is also surely filled.

[0048] Moreover, fn5=fn4- (0.5aluminum+0.15Nb+0.3V+1.3B+0.002) and that come out and a certain shell, and fn 4<=0 and fn 5>=0 are materialized simultaneously do not have the relation of the above fn4 and fn5. From this, promotion of the brittle fracture in fn 4<=0 is considered to be a thing based on the so-called "free dissolution N" based on formation of the carbide of Ti, or a charcoal nitride for promotion of the brittle fracture in fn 5>=0 or fn 3>=0.

[0049] fn6: It begins, when the chemical composition of steel is controlled strictly and the value of the above fn6 is made or more into zero, and a connecting-rod main part and the tensile strength of 800 or more MPas required as connecting-rod KYAPU can be given to non-heat-treated steel. Therefore, it is referred to as fn 6>=0. You may be the maximum (value near 2.23) which especially a limit does not have in the upper limit of this value, and is calculated from fn6.

[0050] Bolthole processing is given to it after being ingoted by the usual method (for example, after the steel which has the above-mentioned chemical composition is really with which the connecting-rod main part 1 and connecting-rod KYAPU 2 were connected fabricated by the object with rolling and forging between the heat by the usual method). Then, it is divided in ordinary temperature by method which was described above to the connecting-rod main part 1 and connecting-rod KYAPU 2. In addition, there is also a thing inside the large end hole which is the part which is really [concerned] going to divide an object if needed (the N section in drawing 1) established for notching of 0.5 or less mmRs in part at least. Subsequently, with a bolt 3, it is combined with a crankshaft and the divided connecting-rod main part 1 and connecting-rod KYAPU 2 are assembled.

[Translation done.]

EXAMPLE

[Example] The vacuum ingot of the steel which has the chemical composition shown in Tables 1-3 was carried out using test kiln by the usual method. The steel 1-34 in Tables 1 and 2 is this invention steel, and the steel 35-48 in Table 3 is the comparison steel from which either of the component separated from the range of the content specified by this invention.
[0052] Subsequently, after making such this invention steel and comparison steel with a slab by the usual method and heating at 1250 degrees C, hot forging was carried out to the round bar with a diameter of 30mm at the temperature of 1200-950 degrees C, and air cooling was carried out to ordinary temperature after that.
[0053] In this way, the JIS No. 4 test piece was cut down from the round bar with obtained hot forging, and the tension test was performed in ordinary temperature. Furthermore, the state of the fracture surface after an ordinary temperature tension test was observed with the scanning electron microscope (SEM).
[0054] In addition, the front face of the round bar which carried out hot forging to 30mm was observed visually, and checked the existence of a forging crack.
[0055] An ordinary temperature tension test result, a fracture surface observation result, and a forging-crack check result are shown in Tables 4 and 5.
[0056] Without each producing a forging crack, if it was in the steel 1-34 which is this invention steel, the desired tensile strength of 800 or more MPas and 10% or less of elongation were acquired, and all the fracture surface after an ordinary temperature tension test was flat brittle fracture appearances. What fills fn 2>=0 also among this invention steel has 0.7 or more yield ratios, and is understood that yield strength is high (above refer to Table 4).
[0057] On the other hand, in the amount of C, and the steel 35 and 48 from which fn6 separated from default value to the low eye, respectively, tensile strength has not reached 800MPa(s) among the comparison steel from which either of the components separated from the range of the content specified by this invention.
[0058] Moreover, the forging crack between heat was accepted in the steel 36-39 and steel 41-46 from which the amount of Si, the amount of Mn, the amount of P, the amount of S, the amount of V, the amount of Nb(s), the amount of Ti, the amount of B, the amount of aluminum, and the amount of Pb(s) separated high to default value, respectively.
[0059] In the steel 40 from which the amount of nickel separated more highly to the default value of this invention, ordinary temperature elongation exceeded 10%, and the fracture surface after an ordinary temperature tension test was a ductile fracture.
[0060] In order that it might separate from the conditions which the value of the above fn1-fn5 specified by this invention in steel 47 and ordinary temperature elongation might exceed 10%, the fracture surface after an ordinary temperature tension test was a ductile fracture (above refer to Table 5).
[0061] Subsequently, it really with which the connecting-rod main part 1 and connecting-rod KYAPU 2 were connected by the usual hot-forging method by being made from the steel 5, 16, 31, and 34 which is this invention steel indicated to the aforementioned table 1 carried out hot forming of the object 20 bodies at a time respectively. In addition, notching of 0.3mmR(s) was attached to the N section of drawing 1 after hot forming every five of 20 bodies. Subsequently, the division test to the connecting-rod main part 1 and connecting-rod KYAPU 2 was performed in ordinary temperature by said method. Consequently, it turns out that a flat brittle fracture appearance is obtained by all 20 bodies, and each steel can be used without the finishing plastic surgery by machining for them. In addition, especially division of each five steel which attached notching was easy.
[0062]
[Table 1]

[0063]
[Table 2]

表　1

区分	鋼種	化学組成（重量%）																残部：Feおよび不純物					
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	1	0.32	0.70	1.19	0.071	0.049	0.02	0.01	0.22	0.01	0.25	-	-	-	0.028	0.0058	0.13	0.70	0.76	0.0010	* 0.0058	*-0.0852	0.2555
	2	0.51	0.38	0.37	0.056	0.042	0.06	0.05	0.18	0.08	0.11	0.025	0.121	0.0031	0.067	0.0152	0.30	0.10	0.08	0.0570	-0.0211	*-0.0974	0.0144
	3	0.54	0.64	0.77	0.072	0.024	0.05	-	0.36	0.16	0.24	0.003	0.093	0.0005	0.025	0.0049	0.11	0.62	0.68	0.0004	-0.0230	*-0.1106	0.4187
	4	0.20	0.68	1.27	0.046	0.056	-	-	0.27	-	0.29	-	0.002	-	0.031	-	-	0.76	0.69	*-0.0051	-0.0006	*-0.1051	0.2219
	5	0.55	0.58	0.49	0.002	0.044	-	0.04	0.25	0.12	0.05	0.011	-	-	0.073	0.0063	0.15	0.18	*-0.11	*-0.0030	* 0.0063	*-0.0489	0.0139
	6	0.33	0.11	0.81	0.063	0.038	0.11	-	0.48	0.46	0.36	0.006	0.084	0.0013	0.097	0.0056	0.18	0.33	0.35	*-0.0061	-0.0196	*-0.1807	0.3789
	7	0.48	0.72	1.46	0.148	0.041	0.08	0.11	0.86	0.05	0.11	0.091	-	-	0.029	0.0061	-	0.44	0.88	0.0012	* 0.0061	*-0.0571	0.3917
	8	0.37	0.57	1.98	0.057	0.054	-	0.48	0.33	-	0.25	-	0.110	0.0024	0.081	0.0033	0.01	0.57	0.56	*-0.0068	-0.0297	*-0.1503	0.4719
	9	0.64	1.47	0.96	0.084	0.046	0.12	-	0.56	0.24	0.08	0.157	-	-	-	0.0063	0.11	1.13	1.25	0.0043	* 0.0063	*-0.0433	0.4054
	10	0.35	0.81	0.56	0.021	0.053	0.19	0.09	0.19	0.11	0.37	-	0.012	-	0.033	-	0.16	1.05	0.86	*-0.0053	-0.0038	*-0.1331	0.3588
	11	0.31	0.18	0.36	0.078	0.081	0.01	-	1.95	0.09	0.26	0.008	0.157	0.0024	0.005	0.0046	-	0.20	0.29	0.0021	-0.0425	*-0.1293	0.4143
	12	0.29	1.20	0.30	0.103	0.011	-	0.20	0.28	-	0.49	-	-	-	0.018	0.0124	0.02	1.68	1.90	0.0086	* 0.0124	*-0.1456	0.5342
	13	0.31	0.74	1.24	0.037	0.047	0.03	0.08	0.68	0.38	0.22	-	0.021	0.0083	0.046	0.0098	0.29	0.68	0.57	0.0032	* 0.0035	*-0.0983	0.3160
	14	0.41	0.27	0.68	0.075	0.096	0.07	0.12	1.24	-	0.18	0.011	-	-	0.024	0.0052	0.14	0.13	0.21	0.0008	* 0.0052	*-0.0645	0.2832
	15	0.30	1.04	0.56	0.048	0.063	-	0.05	0.25	0.02	0.36	0.005	0.118	0.0026	0.059	0.0195	0.17	1.26	1.20	0.0116	-0.0159	*-0.1595	0.3218
	16	0.70	0.16	0.82	0.019	0.007	0.01	0.01	0.04	0.05	-	-	-	-	0.028	0.0060	0.01	*-0.34	*-0.55	0.0012	* 0.0060	*-0.0100	0.0841
	17	0.69	0.16	0.66	0.009	0.063	-	0.03	0.12	-	-	-	-	-	0.004	0.0120	-	*-0.34	*-0.60	0.0096	* 0.0120	0.0080	0.0203

fn1=Si+2V−0.5、　fn2=Si+2V+5P−0.8

fn3=N−0.1Al−0.002、　fn4=N−0.3Ti

fn5=N−0.5Al−0.3Ti−0.15Nb−0.3V−1.3B−0.002

fn6=C+ (Si／10) + (Mn／5) + (5Cr／22) +1.65V− (5S／7) −0.8

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0064]
[Table 3]

表　2

区分	鋼種	化学組成（重量%）																残部：Feおよび不純物					
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	18	0.35	0.70	1.19	0.070	0.049	-	-	0.19	-	0.24	-	0.003	-	0.030	0.0118	0.16	0.68	0.73	0.0068	* 0.0109	*-0.0781	0.2622
	19	0.63	0.22	0.52	0.015	0.015	0.04	-	0.65	0.01	-	0.005	-	-	-	0.0040	-	*-0.28	*-0.51	0.0020	* 0.0040	0.0013	0.0930
	20	0.49	0.50	0.90	0.015	0.055	-	-	0.14	0.03	0.06	-	-	-	0.019	0.0050	0.08	0.12	*-0.11	0.0011	* 0.0050	*-0.0245	0.0115
	21	0.50	0.25	0.90	0.015	0.057	0.05	-	0.13	-	0.12	-	-	-	0.031	0.0070	-	*-0.01	*-0.24	0.0019	* 0.0070	*-0.0465	0.0918
	22	0.53	0.25	0.95	0.017	0.017	0.11	0.03	0.03	0.04	0.10	-	-	-	0.029	0.0075	-	*-0.05	*-0.27	0.0026	* 0.0025	*-0.0390	0.1047
	23	0.32	0.70	1.17	0.069	0.050	-	0.06	0.19	0.01	0.15	0.003	-	-	0.025	0.0100	0.15	0.50	0.55	0.0055	* 0.0100	*-0.0500	0.0790
	24	0.31	0.70	0.78	0.074	0.048	-	-	0.20	-	0.20	-	-	-	0.031	0.0088	0.14	0.60	0.67	0.0037	* 0.0088	*-0.0687	0.0772
	25	0.68	0.31	1.95	0.005	0.095	-	0.24	0.03	0.36	-	-	-	-	0.097	0.0154	-	*-0.19	*-0.47	0.0037	* 0.0154	*-0.0351	0.2400
	26	0.35	0.29	0.48	0.047	-	0.01	-	1.90	0.07	0.01	-	0.018	-	0.014	0.0178	-	*-0.19	*-0.26	0.0144	* 0.0124	0.0004	0.1233
	27	0.31	0.99	1.86	0.073	0.018	0.06	-	0.25	0.24	-	0.004	-	-	0.030	0.0199	0.05	0.49	0.31	0.0149	* 0.0199	0.0023	0.0250
	28	0.63	0.05	0.95	0.018	0.036	-	0.08	0.63	0.42	-	-	0.061	-	-	0.0050	0.08	*-0.45	*-0.66	0.0030	-0.0133	*-0.0153	0.1425
	29	0.37	0.99	1.54	0.015	-	0.08	-	0.51	0.14	0.02	0.011	0.053	0.0006	0.006	0.0125	0.12	0.53	0.31	0.0099	-0.0034	*-0.0168	0.1259
	30	0.67	0.11	0.96	0.073	0.018	0.06	-	0.25	0.24	-	0.004	0.074	-	0.030	0.0124	0.05	*-0.39	*-0.33	0.0074	-0.0098	*-0.0274	0.1170
	31	0.30	0.38	0.95	0.056	0.034	0.16	0.09	1.77	0.11	0.01	0.005	0.108	0.0007	0.098	0.0115	-	*-0.10	*-0.12	*-0.0003	-0.0209	*-0.0766	0.1225
	32	0.35	0.70	1.18	0.056	0.016	-	0.46	1.37	0.07	-	-	0.061	-	0.048	0.0085	-	0.20	0.18	0.0017	-0.0098	*-0.0358	0.1559
	33	0.52	0.29	1.95	0.008	-	-	-	0.74	0.29	-	-	0.095	0.0004	-	0.0097	0.15	*-0.21	*-0.47	0.0077	-0.0188	*-0.0213	0.3072
	34	0.54	0.46	1.43	0.097	-	0.19	-	0.86	0.11	-	0.098	0.003	-	0.099	0.0078	-	*-0.04	0.15	*-0.0041	* 0.0069	*-0.0593	0.2675

$fn1 = Si + 2V - 0.5$、　$fn2 = Si + 2V + 5P - 0.8$

$fn3 = N - 0.1Al - 0.002$、　$fn4 = N - 0.3Ti$

$fn5 = N - 0.5Al - 0.3Ti - 0.15Nb - 0.3V - 1.3B - 0.002$

$fn6 = C + (Si/10) + (Mn/5) + (5Cr/22) + 1.65V - (5S/7) - 0.8$

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0065]
[Table 4]

表　3

区分	鋼種	化学組成（重量%）残部：Feおよび不純物																				
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
比較鋼	35	*0.18	0.68	0.85	0.055	0.051	-	-	0.05	-	0.30	-	0.003	-	0.025	0.0055	-	0.78	0.76	0.0010	* 0.0046	*-0.0999	0.0879
	36	0.64	*1.57	0.96	0.084	0.046	0.12	-	0.56	0.20	0.07	-	-	-	-	0.0066	0.11	1.21	1.33	0.0046	* 0.0066	*-0.0164	0.3989
	37	0.67	0.35	*2.09	0.005	0.081	-	0.08	0.05	0.35	-	-	-	-	0.084	0.0154	-	*-0.15	*-0.43	0.0050	* 0.0154	*-0.0286	0.2765
	38	0.50	0.73	1.46	*0.159	0.042	0.08	-	0.85	-	0.11	0.090	-	-	0.029	0.0060	-	0.45	0.95	0.0011	* 0.0060	*-0.0570	0.4097
	39	0.42	0.28	0.69	0.075	*0.108	0.07	0.11	1.25	-	0.18	0.011	-	-	0.024	0.0055	0.14	0.14	0.22	0.0011	* 0.0055	*-0.0642	0.2899
	40	0.38	0.58	1.95	0.056	0.055	-	*0.55	0.35	-	0.25	-	0.090	0.0024	0.080	0.0033	0.05	0.58	0.56	*-0.0067	-0.0237	*-0.1438	0.4808
	41	0.31	1.18	0.30	0.105	0.081	-	0.20	0.25	0.05	*0.53	-	-	-	0.019	0.0125	0.02	1.74	1.97	0.0086	* 0.0125	*-0.1580	0.5615
	42	0.65	1.40	0.95	0.084	0.089	0.12	-	0.56	0.24	0.08	*0.188	-	-	-	0.0075	-	1.06	1.18	0.0055	* 0.0075	*-0.0467	0.3757
	43	0.32	0.18	0.36	0.078	0.082	-	-	1.90	-	0.27	0.005	*0.245	-	0.010	0.0049	0.15	0.22	0.31	0.0019	-0.0686	*-0.1574	0.4287
	44	0.35	0.74	1.25	0.038	0.045	0.03	-	0.71	0.11	0.21	-	0.021	*0.0109	0.051	0.0105	-	0.66	0.55	0.0034	* 0.0042	*-0.1005	0.3497
	45	0.33	0.10	0.75	0.056	0.041	0.12	-	0.55	-	0.37	-	-	-	*0.105	0.0059	-	0.34	0.32	*-0.0066	* 0.0059	*-0.1596	0.3962
	46	0.41	0.27	0.70	0.072	0.095	0.07	0.12	1.23	-	0.18	-	-	-	0.025	0.0056	*0.34	0.13	0.19	0.0011	* 0.0056	*-0.0629	0.2857
	47	0.55	0.29	1.25	0.012	0.086	-	-	0.58	-	-	-	-	-	0.060	0.0051	-	*-0.21	*-0.45	*-0.0029	* 0.0051	*-0.0269	0.0994
	48	0.51	0.64	0.83	0.062	0.015	0.05	0.03	0.24	-	-	-	-	-	0.025	0.0068	-	0.14	0.15	0.0023	* 0.0068	*-0.0077	*-0.0162

fn1=Si+2V−0.5、　fn2=Si+2V+5P−0.8

fn3=N−0.1Al−0.002、　fn4=N−0.3Ti

fn5=N−0.5Al−0.3Ti−0.15Nb−0.3V−1.3B−0.002

fn6=C+(Si／10)+(Mn／5)+(5Cr／22)+1.65V−(5S／7)−0.8

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

表 4

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
本発明鋼	1	836	1058	0.79	7	脆性	無
	2	812	816	0.75	10	脆性	無
	3	902	1219	0.74	5	脆性	無
	4	830	1037	0.80	8	脆性	無
	5	533	820	0.65	10	脆性	無
	6	914	1187	0.77	7	脆性	無
	7	884	1195	0.74	7	脆性	無
	8	955	1224	0.78	6	脆性	無
	9	858	1208	0.71	6	脆性	無
	10	906	1162	0.78	7	脆性	無
	11	939	1219	0.77	6	脆性	無
	12	1042	1336	0.78	5	脆性	無
	13	877	1124	0.78	8	脆性	無
	14	814	1085	0.75	7	脆性	無
	15	862	1120	0.77	7	脆性	無
	16	505	886	0.57	9	脆性	無
	17	420	824	0.51	10	脆性	無
本発明鋼	18	809	1085	0.76	8	脆性	無
	19	510	895	0.57	9	脆性	無
	20	548	818	0.67	10	脆性	無
	21	582	895	0.65	9	脆性	無
	22	580	907	0.64	9	脆性	無
	23	681	884	0.77	10	脆性	無
	24	681	873	0.78	10	脆性	無
	25	641	1051	0.61	9	脆性	無
	26	608	936	0.65	8	脆性	無
	27	640	831	0.77	10	脆性	無
	28	472	943	0.50	8	脆性	無
	29	731	937	0.78	8	脆性	無
	30	545	924	0.59	9	脆性	無
	31	602	926	0.65	9	脆性	無
	32	752	964	0.78	9	脆性	無
	33	678	1112	0.61	7	脆性	無
	34	805	1073	0.75	8	脆性	無

[0066]
[Table 5]

表 5

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
比較鋼	35	642	792	0.81	10	脆性	無
	36	837	1195	0.70	7	脆性	有
	37	639	1083	0.59	8	脆性	有
	38	871	1210	0.72	6	脆性	有
	39	820	1093	0.75	10	脆性	有
	40	999	1281	0.78	12	延性	無
	41	1065	1366	0.78	5	脆性	有
	42	842	1170	0.72	7	脆性	有
	43	943	1225	0.77	6	脆性	有
	44	1026	1350	0.76	5	脆性	有
	45	920	1195	0.77	7	脆性	有
	46	817	1089	0.75	8	脆性	有
	47	537	895	0.60	29	延性	無
	48	597	796	0.75	10	脆性	無

[Translation done.]

EXAMPLE

[Example] The vacuum ingot of the steel which has the chemical composition shown in Tables 1-3 was carried out using test kiln by the usual method. The steel 1-34 in Tables 1 and 2 is this invention steel, and the steel 35-48 in Table 3 is the comparison steel from which either of the component separated from the range of the content specified by this invention.
[0052] Subsequently, after making such this invention steel and comparison steel with a slab by the usual method and heating at 1250 degrees C, hot forging was carried out to the round bar with a diameter of 30mm at the temperature of 1200-950 degrees C, and air cooling was carried out to ordinary temperature after that.
[0053] In this way, the JIS No. 4 test piece was cut down from the round bar with obtained hot forging, and the tension test was performed in ordinary temperature. Furthermore, the state of the fracture surface after an ordinary temperature tension test was observed with the scanning electron microscope (SEM).
[0054] In addition, the front face of the round bar which carried out hot forging to 30mm was observed visually, and checked the existence of a forging crack.
[0055] An ordinary temperature tension test result, a fracture surface observation result, and a forging-crack check result are shown in Tables 4 and 5.
[0056] Without each producing a forging crack, if it was in the steel 1-34 which is this invention steel, the desired tensile strength of 800 or more MPas and 10% or less of elongation were acquired, and all the fracture surface after an ordinary temperature tension test was flat brittle fracture appearances. What fills fn 2>=0 also among this invention steel has 0.7 or more yield ratios, and is understood that yield strength is high (above refer to Table 4).
[0057] On the other hand, in the amount of C, and the steel 35 and 48 from which fn6 separated from default value to the low eye, respectively, tensile strength has not reached 800MPa(s) among the comparison steel from which either of the components separated from the range of the content specified by this invention.
[0058] Moreover, the forging crack between heat was accepted in the steel 36-39 and steel 41-46 from which the amount of Si, the amount of Mn, the amount of P, the amount of S, the amount of V, the amount of Nb(s), the amount of Ti, the amount of B, the amount of aluminum, and the amount of Pb(s) separated high to default value, respectively.
[0059] In the steel 40 from which the amount of nickel separated more highly to the default value of this invention, ordinary temperature elongation exceeded 10%, and the fracture surface after an ordinary temperature tension test was a ductile fracture.
[0060] In order that it might separate from the conditions which the value of the above fn1-fn5 specified by this invention in steel 47 and ordinary temperature elongation might exceed 10%, the fracture surface after an ordinary temperature tension test was a ductile fracture (above refer to Table 5).
[0061] Subsequently, it really with which the connecting-rod main part 1 and connecting-rod KYAPU 2 were connected by the usual hot-forging method by being made from the steel 5, 16, 31, and 34 which is this invention steel indicated to the aforementioned table 1 carried out hot forming of the object 20 bodies at a time respectively. In addition, notching of 0.3mmR(s) was attached to the N section of drawing 1 after hot forming every five of 20 bodies. Subsequently, the division test to the connecting-rod main part 1 and connecting-rod KYAPU 2 was performed in ordinary temperature by said method. Consequently, it turns out that a flat brittle fracture appearance is obtained by all 20 bodies, and each steel can be used without the finishing plastic surgery by machining for them. In addition, especially division of each five steel which attached notching was easy.
[0062]
[Table 1]

[0063]
[Table 2]

表　1

区分	鋼種	化学組成（重量%）																残部：Feおよび不純物					
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	1	0.32	0.70	1.19	0.071	0.049	0.02	0.01	0.22	0.01	0.25	-	-	-	0.028	0.0058	0.13	0.70	0.76	0.0010	* 0.0058	*-0.0852	0.2555
	2	0.51	0.38	0.37	0.056	0.042	0.06	0.05	0.18	0.08	0.11	0.025	0.121	0.0031	0.067	0.0152	0.30	0.10	0.08	0.0570	-0.0211	*-0.0974	0.0144
	3	0.54	0.64	0.77	0.072	0.024	0.05	-	0.36	0.16	0.24	0.003	0.093	0.0005	0.025	0.0049	0.11	0.62	0.68	0.0004	-0.0230	*-0.1106	0.4187
	4	0.20	0.68	1.27	0.046	0.056	-	-	0.27	-	0.29	-	0.002	-	0.031	-	-	0.76	0.69	*-0.0051	-0.0006	*-0.1051	0.2219
	5	0.55	0.58	0.49	0.002	0.044	-	0.04	0.25	0.12	0.05	0.011	-	-	0.073	0.0063	0.15	0.18	*-0.11	*-0.0030	* 0.0063	*-0.0489	0.0139
	6	0.33	0.11	0.81	0.063	0.038	0.11	-	0.48	0.46	0.36	0.006	0.084	0.0013	0.097	0.0056	0.18	0.33	0.35	*-0.0061	-0.0196	*-0.1807	0.3789
	7	0.48	0.72	1.46	0.148	0.041	0.08	0.11	0.86	0.05	0.11	0.091	-	-	0.029	0.0061	-	0.44	0.88	0.0012	* 0.0061	*-0.0571	0.3917
	8	0.37	0.57	1.98	0.057	0.054	-	0.48	0.33	-	0.25	-	0.110	0.0024	0.081	0.0033	0.01	0.57	0.56	*-0.0068	-0.0297	*-0.1503	0.4719
	9	0.64	1.47	0.96	0.084	0.046	0.12	-	0.56	0.24	0.08	0.157	-	-	-	0.0063	0.11	1.13	1.25	0.0043	* 0.0063	*-0.0433	0.4054
	10	0.35	0.81	0.56	0.021	0.053	0.19	0.09	0.19	0.11	0.37	-	0.012	-	0.033	-	0.16	1.05	0.86	*-0.0053	-0.0038	*-0.1331	0.3588
	11	0.31	0.18	0.36	0.078	0.081	0.01	-	1.95	0.09	0.26	0.008	0.157	0.0024	0.005	0.0046	-	0.20	0.29	0.0021	-0.0425	*-0.1293	0.4143
	12	0.29	1.20	0.30	0.103	0.011	-	0.20	0.28	-	0.49	-	-	-	0.018	0.0124	0.02	1.68	1.90	0.0086	* 0.0124	*-0.1456	0.5342
	13	0.31	0.74	1.24	0.037	0.047	0.03	0.08	0.68	0.38	0.22	-	0.021	0.0083	0.046	0.0098	0.29	0.68	0.57	0.0032	* 0.0035	*-0.0983	0.3160
	14	0.41	0.27	0.68	0.075	0.096	0.07	0.12	1.24	-	0.18	0.011	-	-	0.024	0.0052	0.14	0.13	0.21	0.0008	* 0.0052	*-0.0645	0.2832
	15	0.30	1.04	0.56	0.048	0.063	-	0.05	0.25	0.02	0.36	0.005	0.118	0.0026	0.059	0.0195	0.17	1.26	1.20	0.0116	-0.0159	*-0.1595	0.3218
	16	0.70	0.16	0.82	0.019	0.007	0.01	0.01	0.04	0.05	-	-	-	-	0.028	0.0060	0.01	*-0.34	*-0.55	0.0012	* 0.0060	*-0.0100	0.0841
	17	0.69	0.16	0.66	0.009	0.063	-	0.03	0.12	-	-	-	-	-	0.004	0.0120	-	*-0.34	*-0.60	0.0096	* 0.0120	0.0080	0.0203

fn1=Si+2V−0.5、　fn2=Si+2V+5P−0.8

fn3=N−0.1Al−0.002、　fn4=N−0.3Ti

fn5=N−0.5Al−0.3Ti−0.15Nb−0.3V−1.3B−0.002

fn6=C+ (Si／10) + (Mn／5) + (5Cr／22) +1.65V− (5S／7) −0.8

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0064]
[Table 3]

表　2

区分	鋼種	化学組成（重量%）残部：Feおよび不純物																				
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
本発明鋼	18	0.35	0.70	1.19	0.070	0.049	-	-	0.19	-	0.24	-	0.003	-	0.030	0.0118	0.16	0.68	0.73	0.0068	* 0.0109	*-0.0781	0.2622
	19	0.63	0.22	0.52	0.015	0.015	0.04	-	0.65	0.01	-	0.005	-	-	-	0.0040	-	*-0.28	*-0.51	0.0020	* 0.0040	0.0013	0.0930
	20	0.49	0.50	0.90	0.015	0.055	-	-	0.14	0.03	0.06	-	-	-	0.019	0.0050	0.08	0.12	*-0.11	0.0011	* 0.0050	*-0.0245	0.0115
	21	0.50	0.25	0.90	0.015	0.057	0.05	-	0.13	-	0.12	-	-	-	0.031	0.0070	-	*-0.01	*-0.24	0.0019	* 0.0070	*-0.0465	0.0918
	22	0.53	0.25	0.95	0.017	0.017	0.11	0.03	0.03	0.04	0.10	-	-	-	0.029	0.0075	-	*-0.05	*-0.27	0.0026	* 0.0025	*-0.0390	0.1047
	23	0.32	0.70	1.17	0.069	0.050	-	0.06	0.19	0.01	0.15	0.003	-	-	0.025	0.0100	0.15	0.50	0.55	0.0055	* 0.0100	*-0.0500	0.0790
	24	0.31	0.70	0.78	0.074	0.048	-	-	0.20	-	0.20	-	-	-	0.031	0.0088	0.14	0.60	0.67	0.0037	* 0.0088	*-0.0687	0.0772
	25	0.68	0.31	1.95	0.005	0.085	-	0.24	0.03	0.36	-	-	-	-	0.097	0.0154	-	*-0.19	*-0.47	0.0037	* 0.0154	*-0.0351	0.2400
	26	0.35	0.29	0.48	0.047	-	0.01	-	1.90	0.07	0.01	-	0.018	-	0.014	0.0178	-	*-0.19	*-0.26	0.0144	* 0.0124	0.0004	0.1233
	27	0.31	0.99	1.86	0.073	0.018	0.06	-	0.25	0.24	-	0.004	-	-	0.030	0.0199	0.05	0.49	0.31	0.0149	* 0.0199	0.0023	0.0250
	28	0.63	0.05	0.95	0.018	0.036	-	0.08	0.63	0.42	-	-	0.061	-	-	0.0050	0.08	*-0.45	*-0.66	0.0030	-0.0133	*-0.0153	0.1425
	29	0.37	0.99	1.54	0.015	-	0.08	-	0.51	0.14	0.02	0.011	0.053	0.0006	0.006	0.0125	0.12	0.53	0.31	0.0099	-0.0034	*-0.0168	0.1259
	30	0.67	0.11	0.96	0.073	0.018	0.06	-	0.25	0.24	-	0.004	0.074	-	0.030	0.0124	0.05	*-0.39	*-0.33	0.0074	-0.0098	*-0.0274	0.1170
	31	0.30	0.38	0.95	0.056	0.034	0.16	0.09	1.77	0.11	0.01	0.005	0.108	0.0007	0.098	0.0115	-	*-0.10	*-0.12	*-0.0003	-0.0209	*-0.0766	0.1225
	32	0.35	0.70	1.18	0.056	0.016	-	0.46	1.37	0.07	-	-	0.061	-	0.048	0.0085	-	0.20	0.18	0.0017	-0.0098	*-0.0358	0.1559
	33	0.52	0.29	1.95	0.008	-	-	-	0.74	0.29	-	-	0.095	0.0004	-	0.0097	0.15	*-0.21	*-0.47	0.0077	-0.0188	*-0.0213	0.3072
	34	0.54	0.46	1.43	0.097	-	0.19	-	0.86	0.11	-	0.098	0.003	-	0.099	0.0078	-	*-0.04	0.15	*-0.0041	* 0.0069	*-0.0593	0.2675

fn1=Si+2V−0.5、　fn2=Si+2V+5P−0.8

fn3=N−0.1Al−0.002、　fn4=N−0.3Ti

fn5=N−0.5Al−0.3Ti−0.15Nb−0.3V−1.3B−0.002

fn6=C+(Si／10)+(Mn／5)+(5Cr／22)+1.65V−(5S／7)−0.8

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

[0065]
[Table 4]

表　3

区分	鋼種	化学組成（重量%）残部：Feおよび不純物																				
		C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Al	N	Pb	fn1	fn2	fn3	fn4	fn5	fn6
比較鋼	35	*0.18	0.68	0.85	0.055	0.051	-	-	0.05	-	0.30	-	0.003	-	0.025	0.0055	-	0.78	0.76	0.0010	* 0.0046	*-0.0999	0.0879
	36	0.64	*1.57	0.96	0.084	0.046	0.12	-	0.56	0.20	0.07	-	-	-	-	0.0066	0.11	1.21	1.33	0.0048	* 0.0066	*-0.0164	0.3989
	37	0.67	0.35	*2.09	0.005	0.081	-	0.08	0.05	0.35	-	-	-	-	0.084	0.0154	-	*-0.15	*-0.43	0.0050	* 0.0154	*-0.0286	0.2765
	38	0.50	0.73	1.46	*0.159	0.042	0.08	-	0.85	-	0.11	0.090	-	-	0.029	0.0060	-	0.45	0.95	0.0011	* 0.0060	*-0.0570	0.4097
	39	0.42	0.28	0.69	0.075	*0.108	0.07	0.11	1.25	-	0.18	0.011	-	-	0.024	0.0055	0.14	0.14	0.22	0.0011	* 0.0055	*-0.0642	0.2899
	40	0.38	0.58	1.95	0.056	0.055	-	*0.55	0.35	-	0.25	-	0.090	0.0024	0.080	0.0033	0.05	0.58	0.56	*-0.0067	-0.0237	*-0.1438	0.4808
	41	0.31	1.18	0.30	0.105	0.081	-	0.20	0.25	0.05	*0.53	-	-	-	0.019	0.0125	0.02	1.74	1.97	0.0086	* 0.0125	*-0.1580	0.5615
	42	0.65	1.40	0.95	0.084	0.089	0.12	-	0.56	0.24	0.08	*0.188	-	-	-	0.0075	-	1.06	1.18	0.0055	* 0.0075	*-0.0467	0.3757
	43	0.32	0.18	0.36	0.078	0.082	-	-	1.90	-	0.27	0.005	*0.245	-	0.010	0.0049	0.15	0.22	0.31	0.0019	-0.0686	*-0.1574	0.4287
	44	0.35	0.74	1.25	0.038	0.045	0.03	-	0.71	0.11	0.21	-	0.021	*0.0109	0.051	0.0105	-	0.66	0.55	0.0034	* 0.0042	*-0.1005	0.3497
	45	0.33	0.10	0.75	0.056	0.041	0.12	-	0.55	-	0.37	-	-	-	*0.105	0.0059	-	0.34	0.32	*-0.0066	* 0.0059	*-0.1596	0.3962
	46	0.41	0.27	0.70	0.072	0.095	0.07	0.12	1.23	-	0.18	-	-	-	0.025	0.0056	*0.34	0.13	0.19	0.0011	* 0.0056	*-0.0629	0.2857
	47	0.55	0.29	1.25	0.012	0.086	-	-	0.58	-	-	-	-	-	0.060	0.0051	-	*-0.21	*-0.45	*-0.0029	* 0.0051	*-0.0269	0.0994
	48	0.51	0.64	0.83	0.062	0.015	0.05	0.03	0.24	-	-	-	-	-	0.025	0.0068	-	0.14	0.15	0.0023	* 0.0068	*-0.0077	*-0.0162

$fn1=Si+2V-0.5$、　$fn2=Si+2V+5P-0.8$

$fn3=N-0.1Al-0.002$、　$fn4=N-0.3Ti$

$fn5=N-0.5Al-0.3Ti-0.15Nb-0.3V-1.3B-0.002$

$fn6=C+(Si/10)+(Mn/5)+(5Cr/22)+1.65V-(5S/7)-0.8$

上記の式中の元素記号はその元素の含有量を表す。

*印は本発明の範囲から外れていることを示す。

表 4

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
本発明鋼	1	836	1058	0.79	7	脆性	無
	2	812	816	0.75	10	脆性	無
	3	902	1219	0.74	5	脆性	無
	4	830	1037	0.80	8	脆性	無
	5	533	820	0.65	10	脆性	無
	6	914	1187	0.77	7	脆性	無
	7	884	1195	0.74	7	脆性	無
	8	955	1224	0.78	6	脆性	無
	9	858	1208	0.71	6	脆性	無
	10	906	1162	0.78	7	脆性	無
	11	939	1219	0.77	6	脆性	無
	12	1042	1336	0.78	5	脆性	無
	13	877	1124	0.78	8	脆性	無
	14	814	1085	0.75	7	脆性	無
	15	862	1120	0.77	7	脆性	無
	16	505	886	0.57	9	脆性	無
	17	420	824	0.51	10	脆性	無
本発明鋼	18	809	1065	0.76	8	脆性	無
	19	510	895	0.57	9	脆性	無
	20	548	818	0.67	10	脆性	無
	21	582	895	0.65	9	脆性	無
	22	580	907	0.64	9	脆性	無
	23	681	884	0.77	10	脆性	無
	24	681	873	0.78	10	脆性	無
	25	641	1051	0.61	9	脆性	無
	26	608	936	0.65	8	脆性	無
	27	640	831	0.77	10	脆性	無
	28	472	943	0.50	8	脆性	無
	29	731	937	0.78	8	脆性	無
	30	545	924	0.59	9	脆性	無
	31	602	926	0.65	9	脆性	無
	32	752	964	0.78	9	脆性	無
	33	678	1112	0.61	7	脆性	無
	34	805	1073	0.75	8	脆性	無

[0066]
[Table 5]

表 5

区分	鋼種	降伏強度 (MPa)	引張強度 (MPa)	降伏比	伸び (%)	破面形態	熱間鍛造割れ発生の有無
比較鋼	35	642	792	0.81	10	脆性	無
	36	837	1195	0.70	7	脆性	有
	37	639	1083	0.59	8	脆性	有
	38	871	1210	0.72	6	脆性	有
	39	820	1093	0.75	10	脆性	有
	40	999	1281	0.78	12	延性	無
	41	1065	1366	0.78	5	脆性	有
	42	842	1170	0.72	7	脆性	有
	43	943	1225	0.77	6	脆性	有
	44	1026	1350	0.76	5	脆性	有
	45	920	1195	0.77	7	脆性	有
	46	817	1089	0.75	8	脆性	有
	47	537	895	0.60	29	延性	無
	48	597	796	0.75	10	脆性	無

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the detail of a connecting rod.

[Translation done.]

* NOTICES *

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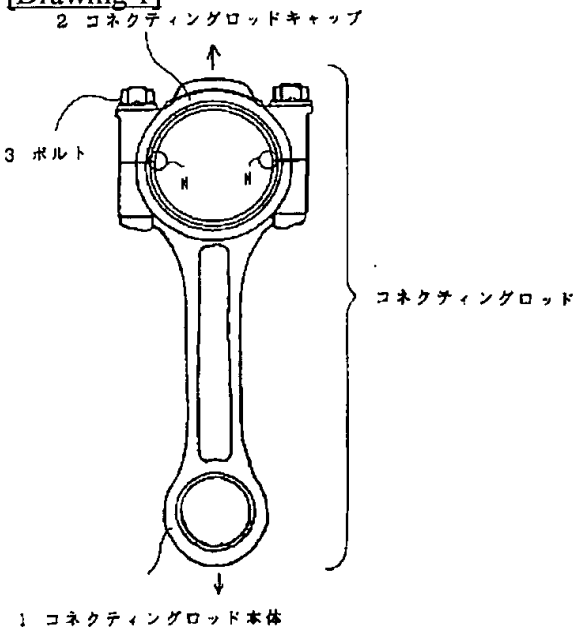
DRAWINGS

[Drawing 1]



[Translation done.]